Further Study of Stickers And Reduced Apple Spray Programs

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FURTHER STUDY OF STICKERS AND REDUCED APPLE SPRAY PROGRAMS

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The work reported herein is a continuation of studies begun several years ago and described in Bulletin 485 [2] of this Station. Since Bulletin 485 was issued in 1945, four wet seasons have served to emphasize more than ever the need for mixtures that resist weathering and continue to give protection after heavy rainfall.

As has been pointed out many times, frequent spray applications are necessary in early season to keep new foliage covered during the period of rapid growth. Nevertheless, the leaves first sprayed (and the fruit as soon as it becomes large enough to hold any quantity of spray) should remain protected and not be reopened, by removal of spray to immediate attack by insects and fungi following heavy rains. Redistribution of spray to parts not covered by the original application is important, but the dividing point between adhesion and redistribution where best control is obtained has not been clearly defined. Work reported in this bulletin indicates that satisfactory all-around pest control is obtainable with programs in which insecticide-fungicide-sticker applications are alternated with fungicides. It does not, however, attempt to define an optimum point in adhesion as regards control.

It is realized, of course, that there is more than one method of obtaining control of pests with a reduced number of sprays. Improved pesticides offer one means. Materials to prevent weathering, the chief concern of this bulletin, afford another. With either method the end result is a saving to the grower in time and labor. In the experiments reported herein, there is a partial combination of both means. Full use of stickers plus the newer chemicals and possibly also the employment of machinery designed for applying concentrates should help still more to lighten the burdens of spraying.

Data presented in Bulletin 485 indicated superior insect control wherever heavy doses of insecticides plus adhesive materials were applied early in the year. Work since then has confirmed the original findings. The present investigations, with somewhat modified techniques, cover some of the phases not considered in that bulletin. We have tried to find substitutes for mineral or vegetable oil stickers, studied various clays and wettable sulfurs as adhesive agents, and have continued reduced schedules in the orchards.

The objectives are the same as those described in Bulletin 485; that is, reduction in the number of sprays necessary to obtain satisfactory pest control. It is felt that only a beginning has been made, and this bulletin is largely a report of progress. The laboratory sticker work builds the necessary

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[1] Entomologist.

[2] See also Bulletin 368, pp. 210-212, and Bulletin 408, pp. 200-205.

foundations and is, of course, preliminary to any field work. Good stickers discovered in laboratory testing are not regarded as proven until field trials are made for pest control and tree injury.

Investigations naturally fall into two parts: (1) laboratory and small scale studies of adhesives, and (2) attempts to reduce the number of sprays in the orchard.

Laboratory and Small Scale Field Experiments with Stickers

LABORATORY TECHNIQUE

In these experiments emphasis has been shifted from glass slides to leaf surfaces. Tests with foliage can be made much more rapidly and are apparently more reliable under a variety of atmospheric conditions. The procedure is simple. Privet (or apple, if preferred) leaves are sprayed for 10 seconds three times, dried and then washed after each spraying with a very heavy regulated wash (equal to 50 inches of rain) at constant pressure (15 pounds) and temperature (20 degrees C). After the third spray and before the third wash, the leaves are allowed to dry overnight at room temperatures. After the third wash differences show up, often in considerable contrast.

The apparatus[1] will take eight different spray treatments at one time so that there is uniformity of treatment among the eight. The leaves can be held for a considerable length of time so that two or three runs can be placed side by side for comparison.

RELATION OF pH TO TENACITY

In some spray mixtures there is apparently a definite relation between degree of acidity or alkalinity and adhesion. In our experiments, it was found that bordeaux mixtures with pH below 7 had relatively poor adhesion compared with those of higher alkalinity. Figure 1 shows results from a combination of bordeaux and flotation sulfur. Similar results were obtained with lead arsenate and talc substituted for the sulfur. Here the copper hydroxide or the copper sulfate hydroxides (1) in bordeaux evidently function as stickers for the lead arsenate, sulfur or talc. Where sulfur is used in combination with bordeaux, it could easily be that copper sulfide is formed, but the similar effect noted with chemicals that are not known to react with copper sulfate would cast doubt on such an hypothesis. Colloids such as copper hydroxide or double salts of hydroxide and sulfate would seem to be the more logical explanation.

It was suggested that spray waters, which vary in Connecticut from pH 5.2 to 7.85, might influence spray tenacity. In comparative tests, however, the various waters used were so nearly alike that no reliable evaluation was possible. Our conclusion, therefore, is that other factors are more important here than pH of the spray waters.

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[1] For description of the apparatus see Bulletin 485, p. 158.

FIGURE 1

Basic formula: Copper sulfate, 2.49 grams; dry flotation sulfur, 5 grams in 418 ml.

	pH
1. Added .26 grams lime	6.5
2. Added .50 grams lime	8.4
3. Added .74 grams lime	10.8
4. Added .98 grams lime	13.5

Upper row unwashed. Lower row sprayed 3 times, washed 3 times.

SULFURS AS ADHESIVES FOR SPRAY MIXTURES

Sulfurs are important components of spray mixtures. What are their effects on adhesion? Are they helpful or detrimental? To answer this question, 12 different wettable sulfurs were tried, both with and without arsenate of lead (Table 1 and 2). They were first used without stickers, then powdered skim milk, .5 gm. per 836 ml., was added and then Wyoming bentonite, 2 gms. to 836 ml., and skim milk were both added. Finally, lime was added and the tests repeated. Results and formulae are given in Tables 1 and 2.

Some of the wettable sulfurs contain adhesives and, as might be expected, the ones having adhesives were not improved by additions. With skim milk alone, the best adhesion was obtained from the pastes and one micronized sulfur (Table 1). With bentonite and skim milk both added, all wettable sulfurs appeared nearly equal except two[1] which were conspicuously inferior. Evidently wetting agents were present in these wettable sulfurs in sufficient quantities to reduce adhesion.

As already shown we learned that not all wettable sulfurs are alike in their adhesion or in having their adhesion improved by skim milk, bentonite, or both. For some, it would obviously not increase adhesion of the spray mix

[1] Flotox and Magnetic Spray.

TABLE 1. EFFECT OF STICKERS ON TENACITY OF WETTABLE SULFUR

Wettable sulfurs	Gms. per 836 ml.	Nothing added	Skim milk added	Skim milk & bentonite	Lime added	Lime & skim milk	Lime, skim milk & bentonite
Kolofog	10.[1]	0[2]	2	2	1	3	3
Magnetic 70 paste	5.8	2	3	3	1	3	3
Flotation sulfur paste	10.	1	3	2	0	2	3
Corona micr.	4.4	1	3	2	0	0	3
Sulforon X	4.4	1	0	2	0	0	3
Flotox	4.4	1	1	0	0	0	3
Mike sulfur	4.4	1	1	2	0	0	3
Eastern States wettable	4.4	1	1	2	0	0	3
Apple dritomic	4.4	1	1	2	0	0	3
Mulsoid	4.4	1	2	2	0	0	3
Magnetic Spray	4.4	1	0	0	0	0	3
Kolospray	4.4	2	2	2	0	1	3

[1] Weights based on sulfur content: designed to give approximately the same sulfur content in each mixture.
[2] Explanation of symbols: 0—no adhesion
1—fair adhesion
2—good adhesion
3—excellent adhesion

TABLE 2. EFFECT OF STICKERS ON TENACITY OF WETTABLE SULFURS, LEAD ARSENATE, AND LEAD ARSENATE AND LIME COMBINATIONS

Wettable sulfurs	Gms. per 836 ml.	Arsenate of lead added to each				Arsenate of lead and lime added to each			
		—	skim milk	skim milk bentonite	bentonite only	—	skim milk	skim milk bentonite	bentonite only
Kolofog	10.	0[1]	3	2	1	2	3	3	3
Magnetic 70 paste	5.8	1	3	3	0	0	3	3	3
Flotation sulfur paste	10.	0	1	3	0	0	3	3	3
Corona micr.	4.4	0	1	2	0	0	2	3	3
Sulforon X	4.4	0	1	2	0	0	2	3	3
Flotox	4.4	1	0	2	0	0	1	3	3
Mike sulfur	4.4	1	0	2	0	0	1	3	3
Eastern States wettable	4.4	0	0	2	0	0	1	3	3
Apple dritomic	4.4	0	0	2	0	0	1	3	2
Mulsoid	4.4	1	0	1	0	0	1	3	3
Magnetic Spray	4.4	1	0	2	0	0	2	3	3
Kolospray	4.4	1	0	2	0	0	2	3	3

[1] Explanation of symbols: 0—no adhesion
1—fair adhesion
2—good adhesion
3—excellent adhesion

to add bentonite (Table 1), while for at least two,[1] neither skim milk nor bentonite and skim milk was of any value. Variable results are to be expected in field experiments unless the same wettable sulfur is used in each case.

Thus, from the standpoint of increased tenacity of the spray by the use of sulfurs, it becomes apparent that only a few of the wettables have reasonably good adhesive properties while most cannot be expected to aid in holding on spray mixtures during rainy weather. This accounts in general for the necessity of repeating wettable sulfur-lead arsenate sprays frequently during wet periods.

[1] Flotox and Magnetic Spray.

CHEMICAL ANALYSIS OF WASHED DEPOSITS

The question of what is adhering in the visual tests as described and figured is a natural one. Can it be bentonite, lead arsenate or sulfur or, in the case of other stickers, can it be the sticker itself? In the case of bentonite-skim milk, the amounts of skim milk are obviously too small to show visually, but deposits could be either bentonite, sulfur or lead arsenate. Previous work (Bulletin 485) showed definitely that lead arsenate adheres better with the sticker than without. Analyses of sulfur show residues of that material also to be materially increased by the sticker. Chemical analyses[1] of uniform spray desposits which had been washed as described gave 1.54 milligrams sulfur per 100 sq. cm. with skim milk alone added, 11.75 milligrams with bentonite and skim milk, and .20 milligrams with no sticker. Thus, with an equivalent of 50 inches of rain in three sprays, there was at the end of the experiment, 7½ times as much sulfur where the spray contained bentonite and skim milk as was found with the same spray plus skim milk alone, and approximately 59 times as much as was found where no sticker was added. Dilution of the sprays was as follows:

		Equivalent in lbs./100 gals.
Lead arsenate	3 grams	3 lbs.
Sulfur	5 grams	5 lbs.
Bentonite	2 grams	2 lbs.
Skim milk	½ gram	½ lb.
Water	800 ml.	100 gals. (approx.)

The above experiment was verified in 1948 in small scale field experiments where trees were sprayed with the same formula as given above and sampled shortly thereafter. The leaf area was calculated and analyses were made then and again 15 days later, after 3.02 inches of rain had fallen. After 15 days, there was a loss of 79.88 per cent of sulfur where no sticker was used and no loss with skim milk-bentonite. Similar results were obtained with soy bean oil at the rate of ½ pint to 100 gallons except that the deposits were not as heavy.

The question as to whether there is an actual advantage in disease and insect control is difficult to prove. Table 17 gives our 1948 results at the Burton Orchard. Evidently the increased resistance to weathering on the part of sulfur with oil stickers added is reflected in better scab control. This corresponds with our 1947 figures as given in Table 13, and to a lesser extent with our 1949 figures. In all these tests, however, the bentonite-skim milk-sulfur-lead arsenate mixtures were no more efficient for disease control, generally less so, than the sulfur-lead arsenate mixtures with no sticker.

CLAYS AND TALCS

Hoping to obtain materials with similar effects on tenacity but more easily miscible with water than Wyoming bentonite, we investigated 24 different clays and talcs used as diluents for insecticides (Table 3). These included Mississippi bentonite, pyrophyllite, celite, talc and others. None of them equalled Wyoming bentonite in sticking properties.

[1] Analyses furnished by the Department of Analytical Chemistry.

The reasons for the better adhesiveness of bentonites that swell on addition of water is not necessarily due to the amounts of Al_2O_3 they contain, as becomes apparent on comparison of the different amounts listed in Table 3

TABLE 3. EFFECT OF CLAYS AND TALCS ON ADHESIVENESS OF SPRAY MIXTURES

Clay	Stick of mixture[1]	pH[2]	Al_2O_3[2] per cent	Particle size[3] (microns)	
1. Argosite clay (Wyoming bentonite)	good to excellent	8.01	19.88	1.3 - 2.5	very fine
2. Volclay bentonite	good to excellent	8.13	20.74	1 - 4	many smaller
3. Kolofog (bentonite-sulfur)	good to excellent	7.29	....	1 or under	very fine
4. Bancroft	good	6.96	39.2	1.3 - 6.5	very fine
5. Cherokee	good	7.18	38.26	1.3 - 6.5	very fine
6. Inert C	fair to good	7.36	38.19	1 - 4	very fine
7. Borden (Kaolin)	fair to good	7.30	37.94	1.3 - 2.5	very fine
8. Sax	fair to good	7.33	39.0	1 - 7	many large particles
9. Homer	poor to fair	7.61	42.70	3 - 7	some very large
10. Tamfloss	poor to fair	7.40	39.19	1 - 2	many large 4 - 20, also many small
11. Pioneer airfloat	poor to fair	7.49	38.14	2 - 7	many large particles
12. Mississippi bentonite	poor	7.82	17.14	10 - 20	large particles
13. Attaclay	poor to fair	8.12	12.5	6 - 13	some very fine
14. Pyrophyllite (Staley NC)	poor	7.51	17.0	16 - 26	very coarse, a few fine
15. Celite	poor	7.39	3.2	2 and up	many long spicules
16. Talc (Loomis)	poor	8.18	....	10 - 30	large
17. Talc (blue)	poor	7.83	9.06	7 - 15	many large, a few small
18. Fuller's earth	poor	8.12	27.37	9 - 19	large particles
19. Type 41 Kaolin	poor to fair	7.45	31.19	1 - 2	very small, mostly under 1
20. Talc (4175)	poor	8.09	.71	7 - 10	a fibrous talc with long spicules
21. Airfloated Hi-white	poor	....	....	1 - 4 - 7	many large particles
22. Unbleached Hydrotex	poor	....	....	1 - 3 - 7	very small, a few large
23. Special Hydrated	poor	....	....	1 - 7	mostly very small, a few large
24. Paragon	poor	....	....	1 - 3	very small

[1] Formula 2 gms. clay, 3 gms. lead arsenate, 5 gms. dry wettable sulfur in 418 ml. (Twice the usual concentration).
[2] Figures from Watkins and Norton.
[3] Microscopic examination.

(from Watkins and Norton, 1947). Likewise, the pH as listed by the same authors does not give any clue. Particle size has some effect; those clays that are finely ground show better adhesion than the clays with coarse particles. This factor alone could easily account for the difference in adhesiveness

between Mississippi and Wyoming bentonites. It is probable, however, that properties, such as the ability to form aluminum gels, which are possessed by the Wyoming bentonites but not by the Mississippi bentonites are partly, if not largely, responsible for the higher tenacity of the former.

Use of another series to determine the proper proportion of Wyoming bentonite and skim milk indicates that for sulfur-lead arsenate mixtures the bentonite should not be reduced below one-fourth the weight of the total solids in the spray mixture (Figures 2 and 3). Furthermore, the amount of

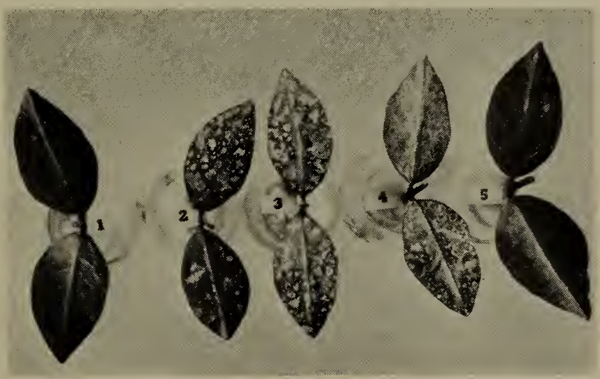

FIGURE 2

1. Lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; Argosite clay (Wyoming bentonite), 2 gms.; water to 800 ml. *No skim milk.*
2. Lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; Argosite clay, 2 gms.; skim milk powder, .5 gms.; water to 800 ml.
3. Lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; Argosite clay, 4 gms.; skim milk powder, 1.0 gm.; water to 800 ml.
4. Lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; Argosite clay, 8 gms.; skim milk powder, 2.0 gms.; water to 800 ml.
5. Lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; skim milk, .5 gms.; water to 800 ml. *No clay.*

Sprayed 3 times, washed 3 times as in previous tests.

skim milk is also optimum at approximately one-fourth the amount of the clay (Figures 3 and 4). Thus, an 8 pounds to 100 gallon concentration would ordinarily require 2 pounds of bentonite and one-half pound skim milk powder.

Various brands of Wyoming bentonite were also tested for speed in mixing with spray ingredients in the laboratory, and those that were more finely ground mixed in much more rapidly with less balling of the bentonite than the coarsely ground preparations. Likewise, in the field, speed of handling was

FIGURE 3

1. Dry wettable sulfur, 8 gms.; lead arsenate, 3 gms.; skim milk, 2 gms.; to 836 ml.
2. Same only skim milk 1 gm.
3. Same only skim milk 0.5 gm.
4. Same only skim milk 0.25 gm.
5. Dry wettable sulfur, 8 gms.; lead arsenate, 3 gms.; bentonite, 8 gms.; skim milk, 2 gms. to 836 ml.
6. Same as 5 only bentonite, 4 gms.; skim milk, 1 gm.
7. Same as 5 only bentonite, 2 gms.; skim milk, 0.5 gm.
8. Same as 5 only bentonite, 1 gm.; skim milk, 0.25 gm.
9. Same as 1 without sticker, neither skim milk nor bentonite.

Sprayed 3 times, washed 3 times in laboratory washer.

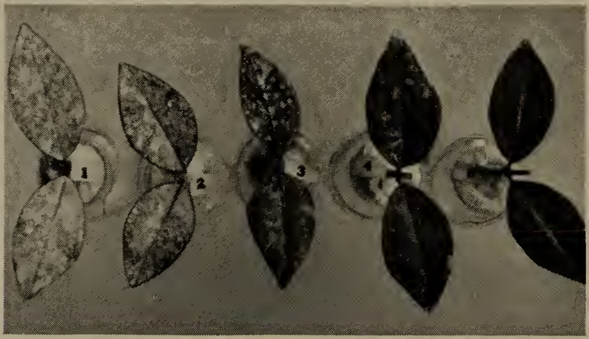

FIGURE 4

1. Lead arsenate, 3 gms.; bentonite-sulfur, 8 gms.; skim milk, 2 gms.; water to 800 ml.
2. Same only skim milk 1 gm.
3. Same only skim milk ½ gm.
4. Same only skim milk ¼ gm.
5. Same but *no skim milk.*

Sprayed 3 times, washed 3 times as in previous tests.

apparently better with the finer bentonites, and it was found that loss of time was negligible wherever these products were first mixed in dry form with the insecticide and fungicide. Addition of the dry mixture (containing all the spray ingredients) direct to the spray tank under agitation avoids the necessity of passing bentonites through the strainer with the resultant clogging due to swelling of the bentonite. We have used such a procedure now for several years entirely without trouble.

FIGURE 5

1. Basic formula: lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; water to 418 ml.
2. Same as 1 plus 4 ml. monochlorobenzene. (Light reflection appears as spray material on lower leaf.)
3. Same as 1 plus 4 ml. α-chloronaphthalene.
4. Same as 1 plus 4 ml. tetrahydronaphthalene.
5. Same as 1 plus 4 ml. butyl phthalate.

Sprayed 10 seconds. Lower row then washed 3 times and resprayed 3 times; washing at 8 lbs. pressure, delivery about 50 inches in the 5 minute period. Upper row sprayed once, unwashed.

OILS AND SULFURS

It was found that small amounts of vegetable oils added to wettable sulfurs improved adhesion of the spray mixtures tremendously. In the laboratory it became apparent that as little as ⅛ pound soy bean oil to 100 gallons was effective. In the field one pint soy bean oil to 100 gallons held the spray satisfactorily. Some leaf burn and drop developed later in the season so the following year, 1948, we reduced the amounts of oil to ½ and ¼ pints per 100 gallons. No leaf injury developed in 1948. In 1949 we added two buffering agents and increased the oil to ½ pint and 1 pint per 100 gallons. There was still no leaf drop or other visible tree injury and the fruit counts indicated a small reduction in the amount of fruit russet for Baldwins.

ORGANIC SUBSTITUTES FOR OILS

It was thought that organic materials having somewhat similar physical properties to mineral and vegetable oils might possibly be substituted, thereby avoiding the conflict between sulfurs and oil. The ones tried include monochlorobenzene, α-chloronaphthalene, butyl phthalate, tetrahydronaphthalene, glycerin and Velsicol A. R. 60. All of these resemble oils in physical properties. There was a considerable difference between α-chloronaphthalene and tetrahydronaphthalene in promoting adherence of the spray mixture. The tetrahydronaphthalene gave almost no increase in adhesion whereas the

FIGURE 6

1. Basic formula: lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; water to 418 ml.
2. Same as 1 plus Velsicol A.R. 60, 4 ml.
3. Same as 1 plus tetrahydronaphthalene, 4 ml.
4. Same as 1 plus α-chloronaphthalene, 4 ml.

Treated as described under Figure 5. Upper row unwashed.

α-chloronaphthalene gave results about equal to mineral oil (Figures 5 and 6). Adhesion with monochlorobenzene was also good. Velsicol A. R. 60 appeared to be only slightly less effective than α-chloronaphthalene. Butyl phthalate and glycerin had no value, and the mixtures containing them washed off completely. Unfortunately, the organic liquids showing adhesion also gave considerable phytotoxicity so there appears to be no chance of substituting any of these for mineral or vegetable oils. The main point brought out in these tests seems to be the marked increase in adhesion from use of the α-chloronaphthalene in comparison with tetrahydronaphthalene; also the good adhesion with monochlorobenzene. The physical properties of the various compounds tested are given below.

Physical constants of organic chemicals used as substitutes for mineral oil

α-chloronaphthalene	Sp. gr. 1.119 Boils 263° C. Insoluble in water—light oil.
Tetrahydronaphthalene	Sp. gr. .9738 Boils 206-207° C. Insoluble in water—oily liquid.
Monochlorobenzene	Sp. gr. 1.107 Boils 131° C. Flash point 28 Insoluble in water—light oil.
Butyl phthalate	Sp. gr. 1.047 Boils 340° C. Slightly soluble in water—thick oily liquid.
Glycerin	Sp. gr. 1.262 Boils 290° C. Soluble in water.
Mineral oil for comparison	Sp. gr. .83 to .90 Boils above 360° C. Insoluble in water

NATURAL AND SYNTHETIC RUBBERS, RESIN EMULSIONS, AND OTHER COMPOUNDS

Synthetic and natural rubber emulsions. Considerable work was done with PVN,[1] a 40 per cent synthetic resin emulsified in a strongly alkaline emulsifier. This was tested for improving adhesion of lead arsenate, benzene hexachloride, toxaphene and chlordane emulsion. All of them except chlordane emulsion were definitely improved. Chlordane emulsion in itself contains a wetting agent that apparently defeats the purpose of the added sticker. Tests both in the field on growing apple trees and in the laboratory show that the effective concentration of PVN should not be below 1 pint to 100 gallons containing 8 pounds of spray solids. Optimum with our waters seems to be around 1 to 2 quarts or 2 to 4 pounds. PVN appears to be fully as good a sticker as bentonite-skim milk. Results of a washing test with PVN are given in Figure 7. Good-rite Latex VL-600, a 50 per cent vinyl chloride latex emulsion, also has excellent adhesive properties. The original material was a milky emulsion which was used at the rate of 1, ½, ¼ and ⅛ pounds per 100 gallons. Tenacity appeared to be good at all levels (Figure 8). Similar results were obtained with natural rubber latex emulsions as shown in Figure 9. Neither of the two latter compounds has been sufficiently field tested to comment further.

Nufilm,[1] a resin residue emulsion, was also tested at recommended concentrations but proved inferior to both bentonite-skim milk and PVN.

Spraylastic,[1] another commerical sticker, was combined with benzene hexachloride and lead arsenate and double strength wettable sulfur. It gave results more nearly comparable to bentonite-skim milk but not quite as good. The tests indicate that a ratio of 1 pound of this sticker to 8 pounds of spray solids must be maintained for good results.

[1] Composition given on p. 37.

FIGURE 7

Basic formula: Lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; water to 418 ml.

1. Basic formula only.
2. Same plus PVN 2 gms.
3. Same plus PVN 4 gms.
4. Same plus PVN 8 gms.

Lower row sprayed 3 times, washed 3 times as described under Figure 5. Upper row sprayed once, unwashed.

FIGURE 8

1. Lead arsenate, 3 gms.; dry wettable sulfur, 5 gms.; VL 600, 1/8 gm.; water to 800 ml.
2. Same only VL 600 1/4 gm.
3. Same only VL 600 1/2 gm.
4. Same only VL 600 1 gm.
5. Lead arsenate, 3 gms.; wettable sulfur, 5 gms.; bentonite, 2 gms.; skim milk, 1/2 gm.; water to 800 ml.

Sprayed and washed as described under Figure 7.

FIGURE 9

1. Lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; natural rubber latex emulsion, 2 gms.; water to 800 ml.
2. Same only latex 1 gm.
3. Same only latex ½ gm.
4. Same only latex ¼ gm.
5. Lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; bentonite, 2 gms.; skim milk powder, ½ gm.; water to 800 ml.

Sprayed and washed as described under Figure 7.

FIGURE 10

1. Lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; Z-1 sticker, 1 gm.; water to 800 ml.
2. Same only Z-1 2 gms.
3. Same only Z-1 3 gms.
4. Same only Z-1 4 gms.
5. Lead arsenate, 3 gms.; dry flotation sulfur, 5 gms.; bentonite, 2 gms.; skim milk, 1 gm.; water to 800 ml.

Sprayed and washed as described under Figure 7.

Z-1,[1] a sticker-spreader, proved to have good adhesive properties when used at the rate of 4 pounds to 100 gallons (including 5 pounds of sulfur and 3 of lead arsenate) (Figure 10).

[1] Composition given on p. 37.

FIELD TRIALS WITH PVN

In a limited field experiment (Table 4) PVN showed considerable value as an adhesive and gave results comparable to those obtained in laboratory tests. Standard wettable sulfur-lead arsenate spray mixtures containing PVN with and without lime were applied to Wealthy trees July 30, 1947. The leaves were sampled immediately, the areas calculated and the deposits analyzed by the Department of Analytical Chemistry. The same trees were then sampled again on August 19 after 2.43 inches of rain had fallen. Loss of lead arsenate and sulfur were estimated from the figures obtained. Comparison of loss determined by chemical analysis and visual examination indicated a general but not complete conformity. As previously determined from laboratory experiments as well as by this field test, good adhesion was obtained from the addition of 2 to 4 pounds PVN (1-2 pounds active ingredient), or an equivalent of one to two quarts, per 100 gallons, with 8 pounds of spray solids in the mixture. The figures also show somewhat better adhesion of mixtures containing no lime, which could easily be because the increased amount of solids in the mixture required an increased amount of sticker.

Table 4. Effect of PVN on Tenacity of Standard Wettable Sulfur-Lead Arsenate Spray Mixtures

Dosage of PVN	Lime added	Residue that remained[1] Chemically estimated: lead remaining	Chemically estimated: sulfur remaining	Visually estimated
		%	%	
.5 lb.	3 lbs./100	66.91	8.82	None
1.0 lb.	3 lbs./100	70.73	24.28	None
1.5 lbs.	3 lbs./100	65.99	....[2]	Slight
2.0 lbs.	3 lbs./100	70.47	24.04	Good
4.0 lbs.	3 lbs./100	89.99	17.27	Good
.5 lb.	None	64.82	0.69	None
1.0 lb.	None	53.18	0.67	Slight
1.5 lbs.	None	72.96	1.36	Slight to moderate
2.0 lbs.	None	81.14	38.14	Good
4.0 lbs.	None	93.41	64.74	Good
Sulfur-lead arsenate lime		44.85	1.17	None
Sulfur-lead arsenate no lime		61.76	.47	None

[1] Period of exposure July 30-August 19 during which there was 2.43 inches of rain.
[2] Sample lost in course of analysis.

That sulfur weathers or disappears at a much faster rate than lead (only the lead in the lead arsenate was determined) from unprotected deposits is evident from the table and may be due in part to sublimation of sulfur. In the case of sprays with PVN, 2 pounds to 100 gallons, sulfur was reduced to

38 per cent of the original load by 2.43 inches of rain whereas lead was cut to only 81 per cent. A proportional rate of reduction may be seen with the 4 pound dose of PVN.

CONCLUSIONS

(1) Stickers may be evaluated in the laboratory using privet or apple leaves. By spraying and washing alternately three times in succession, visual differences become prominent.

(2) Tenacity of spray mixtures, such as bordeaux, is decreased as the pH is lowered below 7. However, spray waters from Connecticut varying from pH 5.2 to 7.85 did not produce any outstanding differences in adhesion when used with standard spray materials.

(3) Twelve wettable sulfurs used for spraying have been tested for their influence on the adhesiveness of spray mixtures. Only a few (notably pastes) have properties enhancing the adhesiveness of spray mixtures.

(4) Bentonites do not act as effective stickers, for the mixtures investigated, unless combined with skim milk or lime.

(5) None of the 24 clays and talcs tested showed as good adhesion as Wyoming bentonite, probably because of the formation of hydrous aluminum gels in the latter on addition of water. The finer the clay, including Wyoming bentonite, the easier to handle.

(6) Improved adhesion for sulfur-lead arsenate mixtures results from as little as ⅛ pound vegetable oil in 100 gallons.

(7) Some organic products similar to oils may improve adhesion, but most of them produced serious foliage injury. α-Chloronaphthalene appeared to adhere better than tetrahydronaphthalene.

(8) Organic sulfurs or other fungicides tested did not seem to influence the adhesive properties of the spray mix.

(9) Synthetic resins are very promising, not only from laboratory, but also from field trials. Both synthetic and natural rubber emulsions have some remarkable adhesive properties. These products equalled bentonite-skim milk stockers in our tests.

Experiments in Reducing the Number of Sprays Needed for Apples

Experiments with reduced spray programs were continued during 1945 to 1949.[1] Results are described in some detail, together with tables covering each year separately. Tests in four orchards are represented, all in different locations and with a varying severity of insect and disease attack. The Westwoods or Plumb Orchard represents the worst conditions for any kind of pest control and is a particularly difficult location in which to control apple scab,

[1] From 1945 to 1948 applications by growers to McIntosh trees ranged from 11 to 22 separate sprays. By "reduced" is meant any number below 11. The minimum used in growers' orchards in 1949 was less though probably no orchard averaged less than 9 per season.

curculio and maggot. The Burton Orchard is intermediate, and until 1947 very little difficulty was experienced there with diseases or insects. The block at the Lyman Orchard used in 1946 was mainly for the study of codling moth in connection with spray reduction.

Formulations for reduced schedule work consisted mainly of lead arsenate, 6 pounds; Fermate, 1½ pounds; bentonite, 2 pounds, and skim milk, ½ pound, using 10 pounds of this mixture to 100 gallons. After 1946 all ingredients except the oil, used to decrease weathering, were mixed together dry before adding water. The oil was added at the time of mixing with water and was emulsified in the spray tank by agitation. No more than two quarts of oil were employed at any time. Only the best white mineral oils were completely safe to the foliage.

The method of spraying was essentially the same as that used in commercial orchards. A 15 gal./min. rig with spray gun and brooms was used in 1945 and during the first part of 1946. In the latter year we acquired a larger outfit, 35 gals./min. Brooms or guns were used depending on the amount of wind. A two-man crew, one driver and one nozzle man, was used in 1946, 1947 and 1948. In 1949, a three-man crew made the applications.

1945 EXPERIMENTS

General Pest and Weather Conditions

Rainfall between May 1 and September 15 was not extremely heavy but was continuous, producing ideal conditions for scab and cedar rust development. Between the dates mentioned, rain fell on 110 of the 138 days (Appendix). Maggot infestations were heavy.

Table 5. Control of Apple Scab With Four Summer Sprays
Burton Orchard, 1945
McIntosh

Plot	Treatment[1] Amounts in lbs. per 100 gals.				Per cent scab	
	Lead ars.	Fermate	Bentonite	Veegum[2]	July 26	Sept. 15
1	6	1½	2	..	5.6	19.8
2	9	1½	2	..	10.9	46.1
3	6	1½	..	5	7.0	40.0
4	9	1½	..	5	7.4	37.8
5	6	3	2	..	2.1	13.8
6	9	3	2	..	1.3	17.2
7	6	3	..	5	2.2	7.8
8	9	3	..	5	2.7	38.4

[1] Spray dates: April 12-13, 30, May 22, July 30 (lead arsenate dust, no fungicide).
[2] Trade name for aluminum magnesium silicate gel. Skim milk powder equal to ½ pound per 100 gallons added to each.

Burton Orchard

The main objectives in 1945 were comparisons of bentonite and aluminum gel (Veegum) as adhesives. Two dosage levels of lead arsenate and two of Fermate were designed to help establish the optimum levels. From data presented in Table 5, it is evident that 3 pounds Fermate to 100 gallons greatly improved scab control. It is also apparent that bentonite gave somewhat better performance than Veegum. Checks made between July 26 and September 15 indicated a four- to nine-fold increase of scab between those dates due to continuous wet weather. Orchard insects were controlled satisfactorily but general pest control was considered unsatisfactory because of scab.

For Baldwins more than 90 per cent clean fruit was obtained with three sprays and one dust (Table 6) and the increased amount of Fermate did not help.

Table 6. Pest Control With Four Summer Sprays
Burton Orchard, 1945
Baldwin

Plot	Treatment[1] Amounts in lbs. per 100 gals.				Per cent clean[2]	Per cent russet	Per cent free of insect and disease blemishes
	Lead ars.	Fermate	Bentonite	Veegum			
1	6	1½	2	..	89.4	7.8	97.2
2	9	1½	2	..	88.7	7.7	96.4
3	6	1½	..	5	88.7	5.7	94.5
4	9	1½	..	5	79.0	16.9	95.9
					Average	9.5	
5	6	3	2	..	90.1	5.0	95.1
6	9	3	2	..	88.8	9.3	98.1
7	6	3	..	5	82.0	15.1	97.1
8	9	3	..	5	87.7	7.9	95.6
					Average	9.3	

[1] Spray dates: April 12-13, 30, May 22, July 30 (lead arsenate dust, no fungicide).
[2] Clean here means free of insect and disease blemishes, figuring russet as a blemish.

The plots were mostly four-tree plots replicated four or five times.

Westwoods Orchard

Conditions for scab and insects, such as curculio and maggot, are much worse here than at the Burton Orchard. The late application for maggot was omitted so that infestations at harvest were too high. In this orchard control of scab on McIntosh was very unsatisfactory, the disease averaging nearly 24 per cent (Table 7). None of the plots received sprays with more than 1½ pounds of Fermate per 100 gallons, although four instead of three (as at the Burton Orchard) early applications were made. Control of pests on Baldwins was only fair because of severe maggot injury but other pests were held to a low percentage (Table 8).

The plots in the Westwoods Orchard were larger than in the Burton Orchard, approximately one acre each, and were not replicated.

Table 7. Pest Control With Four Summer Sprays
Westwoods Orchard, 1945
McIntosh

Treatment[1] Amounts per 100 gals.		Tree	Per cent free of external blemishes	Per cent scab	Per cent curculio	Per cent maggot[2]
Lead arsenate	6 lbs.	H20[3]	51.8	42.9	.81	9.0
Fermate	1½ lbs.	I16	69.1	27.9	.9	.0
Skim milk	½ lb.	K19	73.5	23.5	.0	12.0
White oil	2 qts.	M14	73.2	24.2	.0	.0
Veegum	5 lbs.	O16	68.2	29.9	1.3	11.1
Nicotine sulfate	1 pint in first spray					
		Average	67.2	29.7	.6	6.4
Lead arsenate	6 lbs.	M26	86.0	13.9	.0	6.0
Fermate	1½ lbs.	J33	80.8	15.2	.0	.0
Skim milk	½ lb.	J25	82.4	15.1	.7	.0
White oil	2 qts.	J23	77.8	20.2	1.8	9.6
Bentonite	3 lbs.	K25[3]	57.7	41.1	.0	15.0
Nicotine sulfate	1 pint in first spray					
		Average	77.0	23.9	.5	7.8

[1] Spray dates: April 13-14, May 2, May 24, June 7.
[2] Drop counts only. Picked fruit counts average about half this figure.
[3] Very large dense trees.

Table 8. General Pest Control With Three Summer Sprays
Westwoods Orchard, 1945
Baldwin

Treatment[1] Amounts per 100 gals.		Tree	Per cent clean[2]	Per cent maggot[3]	Per cent curculio	Per cent scab
Lead arsenate	6 lbs.	G15	81.3	22.6	.13	.0
Fermate	1½ lbs.					
Skim milk	½ lb.	G16	78.1	9.4	.14	.14
Veegum	5 lbs.					
White oil	2 qts.	O14	83.3	18.8	2.9	.0
Nicotine sulfate	1 pint in first spray					
Lead arsenate	6 lbs.					
Fermate	1½ lbs.	K32	97.2	20.2	.21	.0
Skim milk	½ lb.					
Bentonite	3 lbs.	K35	92.0	....	3.0	.0
White oil	2 qts.					
Nicotine sulfate	1 pint in first spray					

[1] Spray dates: April 13-14, May 2, May 24.
[2] Free of insect or disease blemishes.
[3] Data indicate need of a later application.

Discussion of 1945 Results

Four sprays gave satisfactory disease control only on Baldwin. At Westwoods with three summer sprays, much maggoty fruit on all varieties indicated a need for better control of that insect. Scab control was unsatisfactory. It will be seen in subsequent pages that single late applications of lead arsenate

apparently had the desired effect on maggot. From the standpoint of the home garden, however, it seems probable that the later application would not be generally needed because a reasonable amount of good fruit was secured without it.

Veegum, in addition to being less effective in pest control than bentonite, has an added disadvantage because it is produced in paste form and cannot be easily mixed with dry insecticides and fungicides. This material was therefore discarded except for buffer experiments in 1949.

1946 EXPERIMENTS

General Pest and Weather Conditions

Rainfall was nearly as heavy during 1946 as in 1945 and, as a result, scab and maggot were again problems. Curculio was worse than usual, but other insects were not troublesome. Between May 1 and September 15, there were 93 days with some rain.

Burton Orchard

Because of the difficulty of obtaining clean fruit on McIntosh (Table 7) in 1945 with four applications, we compared five and six-spray programs with sulfur-lead arsenate schedules of 11 and 12 sprays in 1946. Amounts

Table 9. Summary of Pest and Russet Control
Burton Orchard, 1946
McIntosh

Treatment[1]	Clean deducting russet per cent	Clean including russet per cent	Scab per cent	Russet[2] per cent
A. Sulfur-lead arsenate—11 sprays	93.2[3]	96.6	1.6	3.4
B. Sulfur-lead arsenate—12 sprays	88.6	93.1	4.4	4.5
C. Tersan-lead arsenate—6 sprays	91.3	92.6	6.3	1.3
D. Fermate-lead arsenate—5 sprays	88.9	95.3	2.8	7.3
E. Puratized-Fermate-lead arsenate—5 sprays	86.7	90.8	6.5	4.0

[1] For more complete information see p. 25.

[2] Russet includes net russetting and sulfur scald as well as enlarged lenticels conspicuous enough to reduce sale value. Scoring difficult because of hail-damaged fruit.

[3] Averages of all trees scored in several randomized plots.

Table 10. Summary of Pest Control
Burton Orchard, 1946
Baldwin

Treatment[1]	Clean deducting russet per cent	Clean including russet per cent
A. Lead arsenate-wettable sulfur-lime—11 sprays	77.6	96.9
B. Same as A only 12 sprays	76.6	97.8
C. Tersan-lead arsenate—6 sprays	91.7	96.6
D. Fermate-lead arsenate—5 sprays	89.9	98.2

[1] For more complete information on sprays and dates see p. 25.

of clean fruit were almost equal for both programs. Although the percentage of clean fruit was slightly higher for the regular sulfur program, the difference was not more than 2 to 3 per cent for McIntosh (Table 9). Baldwin fruit from reduced program treatments was much superior due to partial elimination of russetting (Table 10). Residues of lead and arsenic at harvest are given in Table 11. The plots were four tree plots replicated four to five times for each program.

Table 11. Lead and Arsenic Determinations From Harvested Apples
Burton Orchard, 1946

Treatment	As_2O_3 grains/lb.[1]	Lead grains/lb.[1]
A. Sulfur-lead arsenate—11 sprays[2]	.079-.099	.017-.066
B. Sulfur-lead arsenate—12 sprays	.036-.046	.032-.089
C. Tersan-lead arsenate—6 sprays	.049-.063	.066-.070
D. Fermate-lead arsenate—5 sprays	....	.023-.036
E. Puratized-lead arsenate—5 sprays	.056	.036-.041

[1] Official tolerances for arsenic are .025 grain/lb.; for lead, .50 grain/lb. Where no figures are given for As_2O_3, the amounts were considered below tolerance because of the low lead figures.

[2] See following page for more complete information.

Westwoods Orchard

In 1946 we began experimenting with scab control supplements, using Fermate and Puratized. Here with one Fermate and one additional Puratized, or two Fermate supplements, the amount of scab was reduced to 10-16 per cent, beginning to approach satisfactory levels for severe weather conditions and a bad location. Approximately the same results were obtained with Romes. Baldwins, as might have been predicted, came through with better than 90 per cent clean fruit. Maggot control was, however, satisfactory only where a late application of lead arsenate was made. The plots varied from five to 12 trees and were replicated twice.

Lyman Orchard

Feeling that codling moth might be an important factor in any reduced spray program, we tried three efficiency mix applications supplemented by as many complete sulfur dusts. Scab control was not considered satisfactory, although counts in one plot averaged much below 10 per cent. Applications of DDT on June 19-22 reduced the percentage of codling moth injured fruit noticeably, but the difference was not more than 2 per cent. Owner sprayed areas outside the test plots, however, showed almost no codling moth injured fruits.

We were somewhat disappointed to see European red mites come into the test plots in fairly large numbers but were not entirely certain whether to attribute this to migration from outside, or to the sulfur and DDT which are known to influence mite populations. However, since large numbers of mites were present in surrounding blocks, the migration factor was thought at the time to be very important.

TABLE 12. SPRAY SCHEDULES AND FORMULAE FOR TABLES 9, 10, 11
Burton Orchard, 1946

Treatment	Dates	Materials and concentration in pints or pounds per 100 gallons
A, 11 sprays	April 17	Wettable sulfur 8.
	April 24	Lead arsenate 3, sulfur 4, lime 3.
	May 10	Wettable sulfur 4.
	May 17, 23, 29-31, June 7, 17, 25	Lead arsenate 3, sulfur 4, lime 3.
	July 5, 25	Lead arsenate 2, sulfur 2, lime 2.
B, 12 sprays	April 17, 23, 24, May 10	Sulfur 8.
	May 17, 23, 29, June 7, 17, 25	Lead arsenate 3, sulfur 4, lime 3.
	July 5, 25	Lead arsenate 2, sulfur 2, lime 2.
C, 6 sprays	April 17	Fermate 2.
	April 24, May 10, 29, June 12	Special Tersan formula[1] 10.
	July 15	Tersan 2.
D, 5 sprays	April 17	Fermate 2.
	April 24, May 10, 29, June 12	Special Fermate formula[1] 10.
E, 5 sprays	May 10	Puratized ½ pint.
	May 17	Puratized 1 pint, lead arsenate 6, soy bean oil 1 pint, skim milk ½.
	May 29, June 12	Lead arsenate 6, soy bean oil 1 pint.
	July 15	Fermate 2.

[1] Special formula—Lead arsenate 6 lbs.
Fermate or Tersan 2 lbs.
Bentonite 1½ lbs.
Skim milk ½ lb.
Where necessary to increase the Fermate or Tersan, this was added at the time of dilution.

Discussion of 1946 Results

In view of the 1946 results, it became apparent (1) that Tersan-lead arsenate mixes produced fruit of excellent quality but were not quite as effective as Fermate-lead arsenate. This has been corroborated in later experiments. The reason probably lies in the fact that Tersan is only 50 per cent active, whereas Fermate contains 75 per cent active ingredients. They were used in the first tests at the same concentrations. In view of the superior color and finish of the fruit, however, it was decided to keep Tersan or its active ingredient under test until its efficiency could be proved or disproved. (2) It is evident that the only treatment that produced fruit below tolerance was "D", consisting of five sprays of Fermate-lead arsenate. In this series there were four special efficiency mix formula sprays and one of Fermate only. It becomes apparent, therefore, that more than four efficiency mixes cannot be safely applied because of danger of excessive residues. On the other hand, it is well to keep in mind that 10 to 11 sprays of sulfur-lead arsenate also produced over-tolerance residues this year. It is interesting to note that residues obtained with five and six sprays were almost equal to the 10 to 12 spray program, a fact that is reflected in the insect control. In view of these findings, it was further decided to use as few efficiency mix applications as possible (not more than four, preferably three) and not apply any after June 15; also, to recommend dust applications for maggot wherever needed and feasible.

1947 EXPERIMENTS

General Pest and Weather Conditions

Pest control conditions in 1947 were similar to the two preceding seasons, though, if anything, worse for diseases. Curculio infestations began late because of cool weather, but continued late. Maggot infestations were about the same as in 1945 and 1946. Between May 1 and September 15, some rain fell on 98 days.

Burton Orchard

No reduced programs were carried on in the Burton Orchard in 1947, but a comparison of sulfur-lead arsenate with and without soy bean oil as a sticker showed some improvement for soy bean oil (Table 13).

Table 13. Comparison of Lead Arsenate-Wettable Sulfur With and Without Soy bean Oil, 1 Pint to 100 Gallons (Same number of sprays for each)
Burton Orchard, 1947
McIntosh

Treatment[1]	Per cent good	Per cent curculio	Per cent scab	Per cent maggot	
Oil sticker	70.65	4.2	23.8	9.8	Av. of 3 plots
No oil	58.1	3.7	36.5	18.7	Av. of 4 plots

[1] Applications: May 12, 24, June 12-13, July 2-3, 23.
Special scab spray on both plots; Phygon, June 2; Puratized, June 9.
Formulae: Lead arsenate 3 lbs., wettable sulfur 4-5 lbs. to 100 gallons, soy bean oil 1 pint to 100 gallons.

The tests show a distinct advantage in adding oil for both maggot and scab control. Foliage burn appeared to be much worse on the oil-treated plot, especially late in the season, but the figures are interesting nevertheless in indicating an advantage for the oil sticker.

Special Efficiency Mix

Up to 1947, oil was added only after the dry ingredients had been mixed with a small amount of water in the spray tank. In 1947, we added one quart of industrial white oil to every 10 pounds of dry-mixed formula. While the combination is a little heavy, it handles nicely in the spray tank and avoids the necessity of adding the ingredients in different lots. The formula for 100 gallons used in 1947 is as follows:

Lead arsenate	6 lbs.
Fermate or Tersan	2 lbs.
Bentonite	1½ lbs.
Skim milk powder	½ lb.
White mineral oil	1 quart

Westwoods Orchard

Continued experiments with reduced programs were carried on only in the Westwoods Orchard this year. Several supplemental sprays were tried for scab and there was a late application for apple maggot in all plots. The best we could do with McIntosh this year even with a total of eight summer sprays was 85.7 per cent clean fruit (Table 14). However, the picture for Romes is much better since the average amount of clean fruit was well above

TABLE 14. SUMMARY OF PEST CONTROL WITH REDUCED SCHEDULES
Westwoods Orchard, 1947
McIntosh

Treatment[1]	Tree	Per cent free of external blemishes	Per cent curculio	Per cent maggot	Per cent scab
Tersan-lead arsenate special mix[2] supplemented with Phygon 8 sprays	F24	81.4	6.4		13.1
	F26	71.1	1.4		27.6
	M23	82.1	1.6		16.3
	O24	64.0	2.2		34.3
	Average	71.8	2.8	.79	25.8
Tersan-lead arsenate special mix supplemented with Tersan 8 sprays	H24	78.1	2.2		20.5
	H26	87.5	1.6		10.9
	K20	95.4	1.0		5.5
	P37	85.4	2.0		12.0
	Average	85.7	1.7	.61	13.1
Fermate-lead arsenate special mix supplemented with Puratized 8 sprays	I20	93.1	0.0		6.9
	J21	95.8	1.6		2.6
	K39	75.8	7.2		17.1
	M39	67.7	9.9		23.3
	O30	78.3	5.5		17.7
	Average	83.0	4.4	2.4	13.3

[1] For schedule of treatments see p. 28.
[2] Formula on p. 28.

TABLE 15. REDUCED SCHEDULES FOR CONTROL OF PESTS
Westwoods Orchard, 1947
Rome

Treatment	Per cent free of blemishes	Per cent curculio	Per cent scab
Fermate-lead arsenate supplemented with Puratized	99.8	0.0	.16
	85.5	2.3	10.85
	79.4	1.3	16.23
Average	93.6	.80	4.93
Tersan-lead arsenate supplemented with Phygon	96.7	0.0	2.6
	93.1	.8	6.0
	87.6	.6	5.2
Average	93.7	.5	4.6
Tersan-lead arsenate supplemented with Tersan	93.3	.0	5.6

Note: Fruit free of maggot but not listed.

90 per cent. Both curculio and maggot were handled satisfactorily in spite of bad years for both. Although no counts of Baldwins were made except for maggot, the fruit was just as clean as in previous years. The results emphasize the work of 1945 and 1946 which showed that one late July spray is necessary for maggot. The tests also show that the late spray should contain some kind of fungicide when used on McIntosh in seasons similar to 1947.

The plots consisted mostly of three to five trees each and were replicated three times. The experimental design could have been improved by inclusion of a sulfur-lead arsenate standard but comparisons of the treatments are interesting nevertheless. For example, it is important that Tersan and Fermate produced fruit equally clean; also, that curculio injury was so low in all treatments.

Formulae

Lead arsenate	6.0 lbs.	Mixed dry in a mechanical mixer and used at 10 pounds in 100 gallons.
Fermate or Tersan	2.0 lbs.	
Bentonite	1.5 lbs.	
Skim milk	.5 lb.	

White mineral oil added at time of dilution in the spray tank

Supplements for scab control

Phygon	.5 lb. to 100 gals.
Tersan	2.0 lbs. to 100 gals.
Puratized	1.0 pint to 100 gals.

Spray dates

April 15	All plots, oil emulsion.
April 29	Tersan, Phygon, Puratized only.
May 12	Special formula given above.
May 24	Tersan, Phygon, Puratized only.
May 25	Special formula given above.
June 9	Tersan, Phygon, Puratized only.
June 11	Special formula given above.
July 25	Lead arsenate, 3 lbs. to 100 gals. on all plots—no fungicide.

Discussion of 1947 Results

Having found that small amounts of vegetable oil increased adhesion of wettable sulfurs, it is interesting to note that there was actually some pest control increase under 1947 conditions. Continued efforts along this line seemed to be indicated.

The efficiency mixes tested in 1947 were confined to Tersan and Fermate-lead arsenates and were supplemented with such materials as we thought might aid in disease control. Tersan, Phygon and Puratized, applied between the efficiency mixes or before the first, appeared promising enough to continue another year. Thus, from the results to date, it would seem that the proper procedure would be to apply sprays that do not re-distribute, interspersed with those that do. This theory, as will be seen, was tested again in 1948 and 1949.

1948 EXPERIMENTS

General Pest and Weather Conditions

Throughout 1946, 1947 and 1948 disease control conditions became progressively worse. During the early season of 1948 rain was of almost daily occurrence, a condition resulting in heavy scab infection throughout the State. Many authorities pronounced it to be the worst scab year in their experience. Curculio abundance was about normal.

Westwoods Orchard

Trees in the Westwoods Orchard, where our 1948 tests were made, had become even more crowded than the year before so that there was increased difficulty in obtaining good even coverage with our spray outfit.

This year we tried a mixture composed of Arasan[1] (50 per cent TMTD), in place of Tersan, with very poor results—low scab control and some leaf burn. At the same time we continued work with Fermate mixes as in previous years. The main objective was to find how many sprays would be needed for varieties such as Rome, Baldwin and McIntosh in a location such as Westwoods where diseases and insects are difficult to handle. Fair, but not completely satisfactory, results were obtained with McIntosh, using seven and eight sprays. A comparison of Fermate-lead arsenate-sticker sprays with lead arsenate and flotation sulfur paste indicated that it would take at least six Fermate-lead arsenate sprays to equal nine of sulfur-lead arsenate. For Rome, six sprays with similar efficiency mixtures gave 91 per cent clean fruit. For Baldwin, only four were required and the fruit was in much better condition than that obtained with the sulfur-lead arsenate schedule. Results are given in Table 16.

The plots consisted of three to nine trees each and were replicated four times. The formulae used were the same as in 1947 and the schedule of application is shown on page 30.

Table 16. Further Tests of Reduced Schedules for Control of Apple Pests
Westwoods Orchard, 1948

Treatment	Per cent free of blemishes	Per cent scab
Baldwin		
1) 8 sprays (3 special formula, p. 28)	84.3	1.8
2) 7 " " " " " "	84.3	1.7
3) 7 " " " " " "	100.0	0.0
4) 6 " " " " " "	83.1	2.4
5) 4 " " " " " "	92.6	0.0
6) 9 " sulfur-lead arsenate	80.3	0.0
Rome		
1) 8 sprays (3 special formula, see p. 28)	95.0	1.9
2) 7 " " " " " " "	94.4	1.7
3) 6 " " " " " " "	91.7	6.9
4) 9 " sulfur-lead arsenate	77.9	12.6
McIntosh		
1) 8 sprays (3 special formula, see p. 28)	78.0	8.6
2) 7 " " " " " " "	74.5	20.3
3) 7 " " " " " " "	87.0	9.7
4) 6 " " " " " " "	71.7	13.1
5) 6 " " " " " " "	49.3	45.9
6) 4 " " " " " " "	54.6	37.6
7) 9 " sulfur-lead arsenate	73.0	16.3

[1] Formulation used for seed disinfection.

Outline of Spray Program for 1948

	Prepink	Pink		Calyx		2-weeks		1st maggot	2nd maggot
1)	*	‡	*	‡	*	‡		†	†
2)	*	‡	*	‡	*	‡			†
3)	*	‡	*	‡		‡		†	†
4)	*	‡	*	‡		‡			†
5)	*	‡		‡		‡		†	†
6)		‡		‡		‡		†	
7)	*	†	†	†	†	†	†	†	†
Dates	4/50	5/1	5/10	5/19	5/28-9	6/10	6/22	7/7	7/26

Notes: * Fungicide only (Fermate)
† Fungicide plus lead arsenate
‡ Fungicide plus lead arsenate plus sticker (special formula see p. 25)

Burton Orchard

In addition to the tests mentioned, a series of stickers was combined with sulfur-lead arsenate to determine the effects on pest control. These results are given in Table 17. They show a general trend similar to that obtained in 1947 in scab control (Table 13) and the oil stickers appear to be somewhat better than the bentonite-skim milk. However, direct comparison in this case is not advisable inasmuch as there were fewer applications on the trees sprayed with bentonite-skim milk. It is interesting to note that in 1948 there was no delayed leaf burn from the sulfur-oil-arsenical sprays and no increase in russetting on McIntosh or Baldwin. There appeared to be a slight reduction in russetting from mixtures containing bentonite-skim milk but this may have been due in part to fewer applications.

Table 17. Scab and Curculio Control With Lead Arsenate-Sulfur Mixtures With and Without Stickers
Burton Orchard, 1948

Variety	Treatment		Per cent scab	Per cent curculio
McIntosh	Lead arsenate-sulfur, *no sticker*	8 sprays	17.7	4.2
	Same with bentonite-skim milk	6 sprays	24.4	6.9
	Same with soy bean oil ½ pint	7 sprays	14.4	8.9
	Same with soy bean oil ¼ pint	8 sprays	11.6	10.0
Gravenstein	Lead arsenate-sulfur, *no sticker*	8 sprays	39.6	5.8
	Same with bentonite-skim milk	6 sprays	54.8	10.5
	Same with soy bean oil ½ pint	7 sprays	19.7	12.5
	Same with soy bean oil ¼ pint	8 sprays	20.4	6.0
Baldwin	Lead arsenate-sulfur, *no sticker*	8 sprays	2.0	1.6
	Same with bentonite-skim milk	6 sprays	2.2	8.6
	Same with soy bean oil ½ pint	7 sprays	1.5	8.6
	Same with soy bean oil ¼ pint	8 sprays	.9	11.9

Note: Materials used: Lead arsenate 3 lbs. to 100 gals.
70 per cent sulfur paste 4 to 6 lbs. to 100 gals.
Bentonite 2 lbs. to 100 gals.
Soy bean oil as indicated in the table.
Skim milk powder ½ lb.

Discussion of 1948 Results

It is evident from the tables given that careful timing of supplementary sprays enables one to equal or improve on the more extended sulfur-lead arsenate schedules. As found previously for Baldwins, it is not necessary to make more than four applications to get commercially clean fruit. With Romes the picture is nearly the same but McIntosh gave fruit equal to the sulfur-lead arsenate schedule only with seven or more applications. The idea of alternating plain fungicides with efficiency mixes again appears to have been effective. About the only point brought out in connection with sulfur-lead arsenate-oil tests was the absence of leaf burn, possibly but not certainly, due to lower oil concentrations than those used in 1947. Results were confusing as regards pest control so further sprays were planned for 1949.

In addition to the experiments described, a comparison of Fermate and TMTD[1] lead arsenate efficiency mixes was obtained at the Cooke Orchard in Branford.[2] Here we obtained verification of 1947 experiments in Westwoods. We began treatments in the TMTD plot with Arasan but foliage burn caused us to shift early in the season to Tersan. Improved color and finish compared with the Fermate plot at the end of the season seemed definitely to support earlier findings.

1949 EXPERIMENTS

General Pest and Weather Conditions

During 1949, weather conditions changed considerably. Rainfall decreased as compared with the three previous years and, instead of diseases, insects became dominant in the pest control picture. However, curculio was only a little above normal in abundance, codling moth increased but slightly and maggot was no worse than usual. Extreme heat in July and August promoted extensive fruit and foliage injury in the form of leaf scorch and scald. This was particularly noticeable in plots receiving the sulfur schedule.

Discussion of 1949 Results

Trees in the Westwoods Orchard were even more crowded than in 1948 so that thorough spraying still remained difficult. As in 1948, attempts were made to find just how many sprays would be needed with our mixes to produce 90 per cent clean fruit or better. Results are given in Table 18. Only in the case of Romes did we reach the 90 per cent level. This was obtained with six or eight sprays as in 1948. In all varieties, however, control with six sprays was equal or better than the control with standard sulfur-lead arsenate using nine sprays, indicating that at least three sprays could be dropped from the schedule without harm. If higher levels of clean fruit are to be reached in this orchard, more sprays will have to be applied with both standard and efficiency mixes. Pure tetramethylthiuram disulfide (TMTD) was used in the mix in place of Tersan and appeared to be satisfactory. As regards interspersal of fungicides and efficiency mixes, general confirmation of the two previous years' results is apparent.

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[1] Tetramethylthiuram disulfide (50%).

[2] Single one-acre plot of each.

TABLE 18. EFFICIENCY SCHEDULES FOR APPLE PEST CONTROL[1]
Westwoods Orchard, 1949

Treatment	No. sprays	No. replicates	Per cent free of blemishes	Per cent curculio	Per cent scab	Per cent maggot
			McIntosh			
1)	4	2	50	5	45	7
2)	6	5	82	4	10	3
3)	8	4	82	4	8	2
4)	9	3	72	8	17	4
			Cortland			
3)	8	2	78	8	13	4
4)	9	2	63	12	25	23
			Rome			
1)	4		81	4	13	..
2)	6		91	2	5	..
3)	8		94	1	3	..
4)	9		89	.4	9	..

[1] Dates and formulae below.

OUTLINE OF SPRAY PROGRAM FOR 1949

	Prepink	Pink		Calyx		2 weeks		First maggot		Second maggot	
1) 4 sprays		*		*		*				‡	
2) 6 sprays	†	*	†	*		*				‡	
3) 8 sprays	†	*	†	*	†	*		‡		‡	
4) 9 sprays	§	§	§	§	§	§	§		§		§

Note: * Efficiency mix—TMTD 1½ lbs., bentonite 2 lbs., skim milk ½ lb., lead arsenate 6 lbs.—10 lbs. to 100 gals.
† TMTD only.
‡ TMTD 1½ lbs. plus lead arsenate 3 lbs. to 100 gals.
§ Sulfur paste 8 lbs. to 100 to June 8. Dry wettable 4 to 100 to July 1, 2 lbs. July 26. Lead arsenate 3 lbs. to 100 throughout except at prepink. No arsenate in prepink.

Spray dates: (1 to 3) Apr. 19, 26, May 6, 16, 26, June 8-9, July 1, 26.
(4) Apr. 19, 26, May 6, 16, 26, June 8-9, 27, July 19, Aug. 5.

Tests of lead arsenate-sulfur with oil-buffer-stickers[1] were continued and with similar results to 1948. The same number of sprays was used in each experiment. Results were disappointing, but there is a general tendency towards improvement in pest control from use of oil stickers the same as in 1947, Table 19. No delayed foliage burn or increased injury to the fruit was noted in these tests. There appeared to be some reduction in russetting on Gravenstein and Baldwin (figures not given), more especially on the Gravenstein, from the buffered mixtures. The buffer used in 1949 is a by-product in the manufacture of Veegum. It is essentially an aluminum magnesium silicate gel.

[1] Materials designed to prevent reaction between sulfur and arsenate of lead.

Table 19. Effect of Adding Oils and Buffers to Standard Sulfur-Lead Arsenate Sprays
Westwoods Orchard, 1949
McIntosh

Treatment	Percentage clean by rows minus scald and russet			
	D	E	F	Averages
Standard—no sticker	71.38	76.12	75.45	74.31
Oil added	65.38	67.44	63.27	65.35
Oil plus Veegum one-half strength	86.12	....	84.11	85.11
Oil plus Veegum full strength	80.55	85.24	80.70	82.19
Oil plus bentonite	73.32	78.19	66.03	72.51

GENERAL DISCUSSION

It is apparent after five years' work that good insect and disease control may be had with considerably less than the number of sprays usually applied. While we never quite reached the 90 per cent level of clean fruit for McIntosh in the worst location, we reached it in 1946 with only six sprays in the Burton Orchard and in 1944 (Bulletin 485) with only three. Comparing standard sulfur-lead arsenate sprays with special efficiency mixes in 1946, we did almost as well with six Tersan-lead arsenate sprays as we did with 11 to 12 sulfur-lead arsenate applications. Supplemented Fermate-lead arsenate schedules have also given better fruit in our worst location with at least three less sprays. One of the outstanding features of the work has been the consistent performance of tetramethylthiuram disulfide (TMTD) as compared with Fermate in the "efficiency" mixes. In all experiments, with the exception of those in which Arasan, the seed disinfectant, was used, the fruit was notably of better color and finish at harvest than fruit sprayed either with sulfur or Fermate. Disease control was not successful where the amount of TMTD active ingredient was reduced below that of ferric dimethyl-dithiocarbamate.

So far we have been able to equal nine sulfur-lead arsenate sprays on McIntosh with six sprays, including three containing increased lead arsenate with spreader-sticker and a fungicide (iron carbamate or TMTD), supplemented with straight fungicide or insecticide at critical periods. This applies to our worst location. For Romes, however, even in such an unfavorable location, we have needed a maximum of six sprays and for Baldwins only four. It thus becomes apparent that the same degree of control can be had if the right materials are used (in this case efficiency mixes as described previously) with at least three less sprays than are necessary with mixtures in current use. The question naturally arises regarding costs. Is this saving worth the effort?

The following costs have been estimated based on 1949 prices for insecticides. All are for 100 gallon units.

1. *Five sprays* (3 Fermate efficiency mixes plus 2 Fermate supplements)	$10.50 to $11.25
2. *Six sprays* (3 Fermate efficiency mixes plus 3 Fermate supplements)	11.40 to 12.15
3. *Seven sprays* (3 Fermate efficiency mixes plus 4 Fermate supplements)	12.30 to 13.23
4. *Ten sprays* (Lead arsenate-wettable sulfur sprays)	9.81 to 12.97
5. *Ten sprays* (Lead arsenate-Fermate-wettable sulfur sprays)	10.72 to 13.50
6. *Ten sprays* (Lead arsenate-Fermate sprays with sulfur in last two)	14.08 to 15.88

It would seem from this that the cost for materials is considerably less if we compare lead arsenate-Fermate 10 spray programs with three Fermate efficiency mixes plus four supplements (Nos. 3 and 6). When we compare the wettable sulfur programs or combined wettable sulfur-lead arsenate-Fermate programs (Nos. 4, 5, with 3), the low figure is $1.58 per 100 gallons in favor of the wettable sulfur-Fermate-lead arsenate, and $2.49 in favor of the cheaper wettable sulfur-lead arsenate combination. If we consider the more expensive wettable sulfurs, the differences between a seven-spray efficiency mix program and a 10-spray standard are not great, in fact, are slightly in favor of the short program except for the straight sulfur-lead arsenate combination.

However, if one subtracts from the cost of efficiency mixes the cost of labor for the additional sprays, the figures are more nearly equal. Thus, assuming that it requires four minutes to spray 100 gallons, allowing some time for the spray being shut off between trees and an equal time for filling, the time spent on three extra sprays would be about 24 minutes. This would mean for a two-man crew an expenditure of 48 minutes, which at 75 cents per hour would be equal to 60 cents. Substracting this charge from the efficiency mix costs brings the five-spray program much below the cost of any other treatment. In the case of the six-spray program the differences are still in favor of the cheaper sulfurs, but there is no difference between it and the sulfur-lead arsenate-Fermate program. In the case of the seven-spray program the costs are only lower than the ten-spray lead arsenate-Fermate schedule. Actually the time consumed is much greater than indicated because of travel back and forth, time for servicing the spray motor and gasoline consumption both in tractor and sprayer. Where there is no central or nearby filling station, it is in many cases probable that at least double the time allotted for the three extra sprays should be estimated, probably more. Add to this the cost for gasoline and the actual expenses for the seven-spray program as compared with 10 begin to appear in a more favorable light.

The small operator, of course, profits most, and it should be remarked that efficiency mixes have become popular for the home gardener in Connecticut during the last year or two. The larger operators argue with justification that they can't afford to take chances with the weather and, consequently, prefer to spray at more frequent intervals for the sake of insurance. We are not arguing with those growers except from the standpoint of better insect control, which we have seen since 1943, and the better condition of the fruit.

Some of our 1949 results in connection with mist blower work proved definitely that a large part of the russetting on Baldwin occurs in mid-summer. Consequently, if we can keep the sprays confined to early season the chances of avoiding much of this is evident. Also, there is the problem of scald from mid-summer sulfur applications. In 1949 this type of blemish ruined between 5 and 10 per cent of the apples in experimental plots. Normally this doesn't occur, but it is always a potential danger. The main objection to the efficiency mix programs has been the tendency in certain years to delay coloring of the fruit. For that reason we have been much interested in the substitution of tetramethylthiuram disulfide for Fermate since this allows full color to develop, as already noted. However, except for the home garden, the use of TMTD remains in the future because the cost of the material, in comparison with those currently employed, is considerably higher.

GENERAL CONCLUSIONS FROM 1945 TO 1949 FIELD TRIALS

At the end of four seasons, using considerably less than the number of sprays employed for successful pest control in commerical orchards, we have been able to obtain reasonably satisfactory control of insects and diseases in the Burton Orchard (1946) on all varieties, and in the Westwoods Orchard on all except McIntosh. During all these years Baldwins have come through in good condition with fewer sprays than commonly used. In general then:

(1) Scab control has been unsatisfactory in bad locations[1] and in wet years for McIntosh with six or less summer applications; satisfactory for Romes with six, and Baldwins with four. The best supplements tried appear to be Puratized, Fermate and Tersan (50 per cent TMTD). Arasan was definitely unsuccessful in 1948 and was discarded because of foliage burn.

(2) Maggot control should include at least one late July spray or dust, preferably around July 20 to 25, or later.

(3) Codling moth, while not severe in most of the plots with reduced numbers of sprays, could be better controlled by at least one application of DDT, as shown in 1946 at the Lyman Orchard.

(4) The European red mite has not been a problem in any of our reduced schedule plots. Tests in growers' hands have in some cases failed to reduce mites because of poor coverage, excessive migration from nearby areas, or perhaps other reasons. In other words control of mites has not always been satisfactory in growers' orchards.

(5) Curculio control has been excellent throughout the experiments, at no time averaging much above 5 per cent punctured fruit, while in a few cases injury disappeared altogether. Efficiency or reduced mixes applied at the beginning of a warm wet spell persist and protect even though rainfall is heavy.

(6) Russetting in general is much less with Fermate or Tersan formulae than with sulfur, and the difference is greater with Baldwin and Delicious than other varieties. Some damage to Duchess foliage resulted from mixtures containing highly refined white oil.

[1] Low-lying orchards with crowded trees.

(7) Finish and color were superior for formulae including Tersan, or TMTD, to those obtained with any other combination of lead arsenate and fungicide. There is a tendency for fruit treated with Fermate to be delayed in coloring, but this is not true of Tersan. Lenticel enlargement with TMTD mixes was observed in 1948 and 1949 but was not as prominent as with Fermate.

(8) Foliage spray burn resulted in 1947 from treatments in which Phygon followed oil too closely. Serious fruit russet was produced by spraying with Phygon alone following or between regular sprays of efficiency mix formulae containing oil.

(9) Both Tersan (50 per cent TMTD), pure TMTD and Fermate are compatible with mixes containing refined (80-100 vis.) white mineral oil. Duchess should probably not be sprayed with such mixtures unless oil is omitted. Only white oils are recommended for the mixes described in this bulletin.

(10) If sulfur is to be used before or after reduced mixes, the oil is best omitted. Adhesion is good without oil, though deposits are not as permanent.

(11) Combinations containing oil and heavy doses of lead arsenate should not be repeated more than three[1] times, the remaining applications being either fungicide only, as in the 1948 and 1949 tests, or a low dose of lead arsenate and fungicide, or DDT and fungicide. Oil containing formulae should be omitted after June 12-15, or during very hot weather if it occurs before that time.

(12) Small amounts of vegetable oil may be added to sulfur-lead arsenate sprays to improve adhesion. While oil stickers in general have little influence on the effectiveness of sulfur-lead arsenate combinations, there was a marked improvement in 1947 from the addition of 1 pint of soy bean oil per 100 gallons. In 1948 and 1949 results were more confused and no conclusions should be drawn except that oils-buffers-sulfurs-lead arsenate seemed to reduce the amount of russetting and prevented delayed foliage burn such as was obtained in 1947.

(13) Analyses by the Department of Analytical Chemistry in 1946 showed that lead residues[2] for two reduced programs were below tolerance whereas several plots following the more frequent schedules were above.

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4. Watkins, T. C., and Norton, L. B. Properties and commercial sources of insecticide dust diluents and carriers. Agr. Insecticide and Fungicide Assoc. New York. 1947.

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[1] Four in very early seasons.

[2] Wherever lead is below tolerance, arsenic will also be below.

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APPENDIX

Description of Chemicals Used

Wettable sulfurs[1]	*Sulfur*	*Ash*
1. Kolofog	32.05	55.13
2. Magnetic 70 paste	75.90	1.27
3. Flotation sulfur paste	56.71	3.45
4. Micronized	93.97	3.58
5. Sulforon	93.90	3.59
6. Flotox	96.57	1.50
7. Mike sulfur	95.22	2.21
8. Eastern States wettable	90.01	8.33
9. Apple dritomic	85.46	11.63
10. Magnetic Spray (dry)	95.30	3.26
11. Mulsoid	97.96	.19
12. Kolospray	80.00	plus clay and trisodium phosphate

Arasan .... 50% tetramethylthiuram disulfide
Bentonites and clays[2] .... For composition see Watkins and Norton, 1947
Fermate .... 75% ferric dimethyldithiocarbamate
Good-rite latex VL 600 .... 50% vinyl chloride resin latex
Nufilm .... Resin residue emulsion
Phygon 2,3-dichloro-1,4-naphthoquinone
Puratized .... Phenylmercuritriethanolammonium lactate
PVN .... 40% polyvinyl butyl ether
Spraylastic .... 81% petroleum oil plus synthetic wetting agent
Tersan .... 50% tetramethylthiuram disulfide
Veegum .... Aluminum magnesium silicate gel
Velsicol A. R. 60 .... Alkylated naphthalene
Z-1 .... Silica-soap preparation

[1] Analyses by Dr. L. G. Keirstead.
[2] Argosite clay is a Wyoming bentonite.

Rainfall Data, 1945-1949[1]

Year	Month	Inches	Number rainy days	Per cent rainy days
1945	May	6.85	30	96.8
	June	2.53	19	63.3
	July	3.97	25	80.6
	August	3.70	21	67.7
	Sept. 1-15	1.16	15	100.0
Totals and average		18.21	110	79.7
1946	May	6.18	25	80.6
	June	2.99	19	63.3
	July	3.14	13	41.9
	August	7.95	27	87.1
	Sept. 1-15	Trace	9	60.0
Totals and average		20.26	93	67.4
1947	May	4.04	26	83.9
	June	3.83	22	73.3
	July	4.83	25	80.6
	August	3.62	15	48.4
	Sept. 1-15	1.01	10	66.7
Totals and average		16.88	98	70.0
1948	May	5.33	26	83.9
	June	4.49	23	76.7
	July	2.85	15	48.4
	August	3.25	15	48.4
	Sept. 1-15	.09	9	60.0
Totals and average		16.01	88	63.8
1949	May	4.25	17	54.8
	June	.30	5	16.7
	July	3.33	17	54.8
	August	3.65	19	61.3
	Sept. 1-15	2.41	9	60.0
Totals and average		14.94	67	54.5

[1] Normal rainfall for New Haven and vicinity: May, 3.75; June, 4.44; August, 3.79; September (full month), 5.07 inches.